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15 Aug 1992

Dr. Robert Abbey, Scientific Officer
Code 1122MM
Office of Naval Research
800 North Quincy Street
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Dear Dr. Abbey:

Enclosed are three copies of an annual performance report on ONR Grant No. N00014-92-J-1069. Four other copies have been sent to the other addressees listed in the attachment that came with the award.

Although we are still a few months from the beginning of TOGA COARE, John McBride and I have made the anticipated progress with the planning efforts, and I have taken advantage of the TCM90 data set to perform some of the developmental tasks. This grant is thus supporting a portion of my TCM90 work, as we discussed. Due to the fact that all of the COARE work to date has been planning of the experimental design and software development, I did not include figures in this report. I will be producing figures of TCM90 results in the near future and will forward some to you as soon as they are available.

Thank you again for your continued support. Please contact me if additional information is required.

Best Regards,

William M. Frank
Professor

ANNUAL REPORT #1

ONR Grant No. N00014-92-J-1069

The Vertical Distribution of Heating in the Tropical Atmosphere

PIs: William M. Frank and John L. McBride
15 Aug 1992

1. Project Goals

The project is designed to achieve three major goals:

* Assist the planning of TOGA COARE to optimize experimental design and measurement strategy, focussing on the larger scale arrays but paying particular attention to the problem of integrating the measurements from the arrays.

* Participate in the TOGA COARE field program during the IOP.

* Carry out a research program examining the mean properties and vertical heating profiles of mesoscale through synoptic-scale circulation systems in the COARE region, exploring the relationships between these systems and larger scale forcing, and determining the processes that determine the vertical structure of the atmosphere during COARE.

2. First Year Accomplishments

2.1 Planning for COARE

The PIs have participated in the planning of the large-scale rawinsonde array for the IOP, which begins in November 1992. They have most recently attended the COARE planning meetings in Townsville, Australia (Dr. McBride) and the practice simulations in Boulder, CO (Dr. Frank). A considerable amount of the planning effort is being coordinated through an efficient electronic mail effort on OMNET. Dr. McBride is one of the lead coordinators of the Australian participation in the rawinsonde sounding network.

While the main thrust of the research must necessarily await the gathering of the TOGA COARE data set, several preliminary and related activities are underway. These are summarized below:

2.2 Development of Modelling Techniques

Work continues on development of integrated parameterization techniques to be used in the studies of the vertical structure of the atmosphere in the COARE region under different large-scale forcing conditions. The goal is to merge the cloud model developed as part of the Frank and Cohen (1987) cumulus parameterization, and modified by Chen and Frank (1992) with a boundary layer model and a combined radiation and layer cloud parameterization. This physical package will be installed and tested in the new version of the NCAR Community Climate Model (CCMII). The 1-Dimensional and 2-Dimensional test bed versions of CCMII are being developed by personnel at NCAR under other support. The PIs are concerned with developing the integrated physical parameterization package, which will then be installed in CCMII and tested using COARE data.

Two versions of the package are being developed. The first combines a higher-order boundary layer model (level 2.5) with the Frank and Cohen cloud model, a radiative transfer scheme and the stable cloud scheme of Smith (1990). The boundary layer model computes perturbation values of moisture, potential temperature and vertical kinetic energy, which are then being used to initialize spectra of cloud models. This procedure combines the cumulus parameterization and boundary layer into a single system for parameterizing boundary layer structure and turbulence, as well as both shallow and deep convective clouds. The addition of the radiation/stable cloud scheme results in a scheme that handles the major physical processes in one integrated package.

The above package was assembled with the assistance of a visiting postdoctoral scholar at Penn State (Dr. Kathleen McInnes of CSIRO Australia). It was installed in the current version of the Penn State mesoscale model. The boundary layer and radiation/stable cloud parameterizations have been integrated, and the cloud model is currently being added to the scheme. Testing in one-dimensional simulations will begin as soon as the cloud model is operational in that model. Preliminary tests of the scheme without the cloud model have been performed as part of a polar research project and will be presented by Dr. McInnes at a conference in September 1992.

The second version is similar to the first except that it uses a mixed-layer boundary layer model based on Albrecht et. al. (1979) instead of the level 2.5 higher-order boundary layer. This package is being developed as part of the M.S. thesis project of Ms. Caryn Dean, a graduate student at Penn State. The coding of this model package has just been completed, including integration with the Frank and Cohen cloud model, and testing is underway. The tests will examine the equilibrium vertical structure of the environment under different large-scale conditions based on tropical maritime data sets compiled by the PIs. These include data from AMEX (Australian Monsoon Experiment), TCM90 (Tropical Cyclone Motion Experiment 1990),

GATE (GARP Atlantic Tropical Experiment) and several composite data sets. The results will be used to adjust the parameterizations for optimum performance in the TOGA COARE region.

2.3 Vertical Heating Profiles

The task of computing vertical heating profiles for both the IFA (Intensive Flux Array) and larger scale areas must wait until the data are available. In the interim programs are being written to test different budget computation procedures from large-scale tropical rawinsonde arrays using the TCM90 data set. Mr. Tim Marchok, a graduate student at Penn State is evaluating the accuracy of heat and moisture budgets over portions of the northwest Pacific before, during and after typhoons. He is experimenting with different computational methods (primarily line integral and analytical function fitting techniques) and will compare budgets computed with these methods to those performed with objectively analyzed data. In general, objective analysis schemes tend to produce smoother fields, but the other two approaches do a better job of preserving the divergent component of the winds, which is crucial in computing the types of heat and moisture budgets needed in COARE.

The EOF (empirical orthogonal function) analysis technique of Alexander et. al. (1992) will be used to decompose the vertical heating profiles into components for further analysis. This technique was applied by those authors to the AMEX analysis of Frank and McBride (1989) and allowed estimates of the contributions of different diabatic heating processes to the total profile. These results suggest that the procedure will allow us to deduce the nature of the heating over the IFA and portions of the COARE large-scale rawinsonde network as well.

3. Changes in the Work Plan

Changes during the first year of the program were minor and represented small additions to the effort. Data from the TCM90 experiment were used in the development and testing of budget algorithms, and these efforts will be of significant importance to the PI's TCM90 research project as well. No significant changes to the work plans for years 2 and 3 are anticipated.

4. References

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